

CLAIMS

The following listing of claims will replace all prior versions and listings of claims in the application.

LISTING OF CLAIMS

1. (Original) A coupled inductor regulator for converting energy from a source of input voltage to an output having an output voltage, comprising:

at least two conduction switches to conduct energy from the source of input voltage to the output;

at least two inductors in communication with the at least two conduction switches, the at least two inductors wound together on a common core and each inductor having a polarity such that DC currents in the inductors cancel each other, the inductors having a coefficient of coupling approximately equal to one;

at least two freewheeling switches in communication with the at least two conduction switches to provide a path for current during non-conduction periods; and

a drive signal generator to generate drive signals each having a duty cycle of approximately 50%, the drive signals to control the at least two conduction switches.

2. (Original) The coupled inductor regulator of Claim 1 wherein the coefficient of coupling is approximately at least 0.99.

3. (Original) The coupled inductor regulator of Claim 1 wherein the at least two conduction switches, the at least two inductors, and the at least two freewheeling

switches are connected in a buck configuration such that the output voltage is approximately one-half the amplitude of the input voltage.

4. (Original) The coupled inductor regulator of Claim 3 wherein the buck configuration includes two buck regulators each operating at approximately 50% duty cycle, each buck regulator including;

a conduction switch in communication with a freewheeling switch and an inductor, the conduction switch to communicate current during a conduction period from the source of input voltage through the inductor to the output, the freewheeling switch to provide a conduction path during the non-conduction period for current flowing through the inductor to the output.

5. (Original) The coupled inductor regulator of Claim 1 wherein the at least two conduction switches, the at least two inductors, and the at least two freewheeling switches are connected in a boost configuration such that the output voltage is approximately twice the amplitude of the input voltage.

6. (Original) The coupled inductor regulator of Claim 5 wherein the boost configuration includes two boost regulators each operating at approximately 50% duty cycle, each boost regulator including;

a conduction switch in communication with a freewheeling switch and an inductor, the conduction switch to communicate current during a conduction period from the a high side of the source of input voltage through the inductor to a low side of the

source of input voltage, the freewheeling switch to provide a conduction path during the non-conduction period for current flowing from the high side of the source of input voltage through the inductor to the output.

7. (Original) The coupled inductor regulator of Claim 1 wherein the at least two conduction switches, the at least two inductors, and the at least two freewheeling switches are connected in a 1:-1 configuration such that the output voltage is approximately a negative of the input voltage.

8. (Original) The coupled inductor regulator of Claim 7 wherein the 1:-1 configuration includes two flyback regulators each operating at approximately 50% duty cycle, each flyback regulator including;

a conduction switch in communication with a freewheeling switch and an inductor, the conduction switch to communicate current during a conduction period from the a high side of the source of input voltage through the inductor to a low side of the source of input voltage, the freewheeling switch to provide a conduction path during the non-conduction period for current flowing from the output through the inductor to the low side of the source of input voltage.

9. (Original) The coupled inductor regulator of Claim 1 wherein at least one of the conduction switches includes independently controllable parallel switches.

10. (Original) The coupled inductor regulator of Claim 1 wherein the output voltage supplies power to a load; and

further comprising a frequency generator to generate a clock signal having an operating frequency, the drive signals synchronous to the clock signal, and the operating frequency controllable in response to changes in the load.

11. (Original) The coupled inductor regulator of Claim 10 wherein the changes in the load include output current changes and output voltage changes.

12. (Original) The coupled inductor regulator of Claim 1 wherein each of the at least two inductors includes a pair of series inductors, each pair having a common node between the series inductors; and

each of the conduction switches in communication with the common node of a corresponding pair of series inductors.

13. (Original) The coupled inductor regulator of Claim 12 wherein the at least two conduction switches, pairs of series inductors, and freewheeling switches are connected in a buck configuration, the buck configuration including two buck regulators each operating at approximately 50% duty cycle, each buck regulator including;

a conduction switch in communication with a freewheeling switch and the pair of series inductors, the conduction switch to communicate current during a conduction period from the source of input voltage through the pair of series inductors to

the output, the freewheeling switch to provide a conduction path during the non-conduction period for current flowing through one of the series inductors to the output.

14. (Original) The coupled inductor regulator of Claim 12 wherein the at least two conduction switches, the at least two inductors, and the at least two freewheeling switches are connected in a boost configuration including two boost regulators each operating at approximately 50% duty cycle, each boost regulator including;

a conduction switch in communication with a freewheeling switch and an inductor, the conduction switch to communicate current during a conduction period from the a high side of the source of input voltage through the inductor to a low side of the source of input voltage, the freewheeling switch to provide a conduction path during the non-conduction period for current flowing from the high side of the source of input voltage through the inductor to the output.

15. (Original) The coupled inductor regulator of Claim 12 wherein the at least two conduction switches, the at least two inductors, and the at least two freewheeling switches are connected in a flyback configuration including two flyback regulators each operating at approximately 50% duty cycle, each flyback regulator including;

a conduction switch in communication with a freewheeling switch and an inductor, the conduction switch to communicate current during a conduction period from the a high side of the source of input voltage through the inductor to a low side of the source of input voltage, the freewheeling switch to provide a conduction path during the

non-conduction period for current flowing from the output through the inductor to the low side of the source of input voltage.

16. (Original) The coupled inductor regulator of Claim 12 wherein each of the at least two inductors has a quantity of turns, and a turns ratio of the turns for each pair of series inductors is selected to set a voltage ratio of the output voltage divided by the input voltage.

17. (Original) The coupled inductor regulator of Claim 16 wherein the at least two inductors each have approximately an equal quantity of turns such that the output voltage is approximately equal to one-fourth of the input voltage; and

wherein the at least two conduction switches, pairs of two series inductors, and the at least two freewheeling switches are connected in a buck configuration, the buck configuration including two buck regulators each operating at approximately 50% duty cycle, each buck regulator including;

a conduction switch in communication with a freewheeling switch and a pair of series inductors, the conduction switch to communicate current during a conduction period from the source of input voltage through the pair of series inductor to the output, the freewheeling switch to provide a conduction path during the non-conduction period for current flowing through one of the series inductors to the output.

18. (Original) The coupled inductor regulator of Claim 16 wherein the series inductors include a first inductor in communication with one of the conduction switches and a second inductor in communication with the output;

the turns ratio of the series inductors is defined as a quantity of turns of the first inductor divided by a quantity of turns of the second inductor; and wherein the turns ratio of the series inductors is approximately equal to one-half such that the voltage ratio is approximately one-third.

19. (Original) The coupled inductor regulator of Claim 1 wherein the freewheeling switches include synchronous rectifiers.

20. (Original) The coupled inductor regulator of Claim 1 wherein the drive signals include multi-level switching to reduce switching losses.

21. (Original) The coupled inductor regulator of Claim 1 included in a power system, the power system including a low dropout regulator having a first output, the first output being the input voltage to the coupled inductor regulator; and

a feedback signal connected from the output voltage of the coupled inductor regulator to the low dropout regulator, the low dropout regulator to regulate the first output in response to the feedback signal.

22. (Original) The coupled inductor regulator of Claim 1 wherein the common core is made from a high permeability material.

23. (Original) The coupled inductor regulator of Claim 22 wherein the common core is made from a ferrite.

24.-74. (Cancelled)

75. (Original) A coupled inductor regulator for converting energy from a source of input voltage to an output having an output voltage, comprising:

at least two means for conduction switching to controllably conduct energy from the source of input voltage to the output;

at least two inductors in communication with the at least two means for conduction switching, the at least two inductors wound together on a common core and each inductor having a polarity such that DC currents in the inductors cancel each other, the inductors having a coefficient of coupling approximately equal to one;

at least two means for freewheeling switching in communication with the at least two conduction switching means to provide a path for current during non-conduction periods; and

means for generating drive signals; the drive signals each having a duty cycle of approximately 50%, and the drive signals to control the at least two conduction switching means.

76. (Original) The coupled inductor regulator of Claim 75 wherein the coefficient of coupling is approximately at least 0.99.

77. (Original) The coupled inductor regulator of Claim 75 wherein the at least two conduction switching means, the at least two inductors, and the at least two freewheeling switching means are connected in a buck configuration such that the output voltage is approximately one-half the amplitude of the input voltage.

78. (Previously Presented) The coupled inductor regulator of Claim 77 wherein the buck configuration includes two buck regulators each operating at approximately 50% duty cycle, each buck regulator including;

a means for conduction switching in communication with a means for freewheeling switching and an inductor, the conduction switching means to communicate current during a conduction period from the source of input voltage through the inductor to the output, the freewheeling switching means to provide a conduction path during the non-conduction period for current flowing through the inductor to the output.

79. (Original) The coupled inductor regulator of Claim 75 wherein the at least two means for conduction switching, the at least two inductors, and the at least two means for freewheeling switching are connected in a boost configuration such that the output voltage is approximately twice the amplitude of the input voltage.

80. (Original) The coupled inductor regulator of Claim 79 wherein the boost configuration includes two boost regulators each operating at approximately 50% duty cycle, each boost regulator including;

a means for conduction switching in communication with a means for freewheeling switching and an inductor, the means for conduction switching to communicate current during a conduction period from the a high side of the source of input voltage through the inductor to a low side of the source of input voltage, the means for freewheeling switching to provide a conduction path during the non-conduction period for current flowing from the high side of the source of input voltage through the inductor to the output.

81. (Original) The coupled inductor regulator of Claim 75 wherein the at least two means for conduction switching, the at least two inductors, and the at least two means for freewheeling switching are connected in a 1:-1 configuration such that the output voltage is approximately a negative of the input voltage.

82. (Original) The coupled inductor regulator of Claim 81 wherein the 1:-1 configuration includes two flyback regulators each operating at approximately 50% duty cycle, each flyback regulator including;

a means for conduction switching in communication with a means for freewheeling switching and an inductor, the means for conduction switching to communicate current during a conduction period from the a high side of the source of input voltage through the inductor to a low side of the source of input voltage, the means

for freewheeling switching to provide a conduction path during the non-conduction period for current flowing from the output through the inductor to the low side of the source of input voltage.

83. (Original) The coupled inductor regulator of Claim 75 wherein at least one of the at least two means for conduction switching includes independently controllable parallel switches.

84. (Original) The coupled inductor regulator of Claim 75 wherein the output voltage supplies power to a load; and

further comprising means for frequency generating to generate a clock signal having an operating frequency, the drive signals synchronous to the clock signal, and the operating frequency controllable in response to changes in the load.

85. (Original) The coupled inductor regulator of Claim 84 wherein the changes in the load include output current changes and output voltage changes.

86. (Original) The coupled inductor regulator of Claim 75 wherein each of the at least two inductors includes a pair of series inductors, each pair having a common node between the series inductors; and

each of the at least two means for conduction switching in communication with the common node of a corresponding pair of series inductors.

87. (Original) The coupled inductor regulator of Claim 86 wherein the at least two means for conduction switching, pairs of series inductors, and the at least two means for freewheeling switching are connected in a buck configuration, the buck configuration including two buck regulators each operating at approximately 50% duty cycle, each buck regulator including;

a means for conduction switching in communication with a means for freewheeling switching and the pair of series inductors, the means for conduction switching to communicate current during a conduction period from the source of input voltage through the pair of series inductors to the output, the means for freewheeling switching to provide a conduction path during the non-conduction period for current flowing through one of the series inductors to the output.

88. (Original) The coupled inductor regulator of Claim 86 wherein the at least two means for conduction switching, the at least two inductors, and the at least two means for freewheeling switching are connected in a boost configuration including two boost regulators each operating at approximately 50% duty cycle, each boost regulator including;

a means for conduction switching in communication with a means for freewheeling switching and an inductor, the means for conduction switching to communicate current during a conduction period from the a high side of the source of input voltage through the inductor to a low side of the source of input voltage, the means for freewheeling switching to provide a conduction path during the non-conduction

period for current flowing from the high side of the source of input voltage through the inductor to the output.

89. (Original) The coupled inductor regulator of Claim 86 wherein the at least two means for conduction switching, the at least two inductors, and the at least two means for freewheeling switching are connected in a flyback configuration including two flyback regulators each operating at approximately 50% duty cycle, each flyback regulator including;

a means for conduction switching in communication with a means for freewheeling switching and an inductor, the means for conduction switching to communicate current during a conduction period from the a high side of the source of input voltage through the inductor to a low side of the source of input voltage, the means for freewheeling switching to provide a conduction path during the non-conduction period for current flowing from the output through the inductor to the low side of the source of input voltage.

90. (Original) The coupled inductor regulator of Claim 86 wherein each of the at least two inductors has a quantity of turns, and a turns ratio of the turns for each pair of series inductors is selected to set a voltage ratio of the output voltage divided by the input voltage.

91. (Original) The coupled inductor regulator of Claim 90 wherein the at least two inductors each have approximately an equal quantity of turns such that the output voltage is approximately equal to one-fourth of the input voltage; and wherein the at least two means for conduction switching, pairs of two series inductors, and the at least two means for freewheeling switching are connected in a buck configuration, the buck configuration including two buck regulators each operating at approximately 50% duty cycle, each buck regulator including;

a means for conduction switching in communication with a means for freewheeling switching and a pair of series inductors, the means for conduction switching to communicate current during a conduction period from the source of input voltage through the pair of series inductor to the output, the means for freewheeling switching to provide a conduction path during the non-conduction period for current flowing through one of the series inductors to the output.

92. (Original) The coupled inductor regulator of Claim 90 wherein the series inductors include a first inductor in communication with one of the at least two means for conduction switching and a second inductor in communication with the output; the turns ratio of the series inductors is defined as a quantity of turns of the first inductor divided by a quantity of turns of the second inductor; and

wherein the turns ratio of the series inductors is approximately equal to one-half such that the voltage ratio is approximately one-third.

93. (Original) The coupled inductor regulator of Claim 75 wherein the at least two means for freewheeling switching include synchronous rectifiers.

94. (Original) The coupled inductor regulator of Claim 75 wherein the drive signals include multi-level switching to reduce switching losses.

95. (Original) The coupled inductor regulator of Claim 75 included in a power system, the power system including means for low dropout regulating having a first output, the first output being the input voltage to the coupled inductor regulator; and a feedback signal connected from the output voltage of the coupled inductor regulator to the means for low dropout regulating, the means for low dropout regulating to regulate the first output in response to the feedback signal.

96. (Original) The coupled inductor regulator of Claim 75 wherein the common core is made from a high permeability material.

97. (Original) The coupled inductor regulator of Claim 96 wherein the common core is made from a ferrite.

98.-154. (Cancelled)

155. (Original) A coupled inductor regulator for converting energy from a source of input voltage to an output having an output voltage, comprising:

at least two phase signals to control a conduction time;

at least two drivers, responsive to the at least two phase signals, to conduct energy from the source of input voltage;

a lattice network of coupled inductors in communication between the at least two drivers and the output, the lattice network having N stages wherein N is at least one, pairs of inductors within each of the stages each having a coefficient of coupling approximately equal to one;

the phase signals each having a duty cycle of approximately $100\%/2N$;

and

the output voltage approximately equal to the input voltage divided by $2N$.

156. (Original) The coupled inductor regulator of Claim 155 wherein the at least two phase signals have a quantity approximately equal to $2N$.

157. (Original) The coupled inductor regulator of Claim 155 wherein the at least two drivers have a quantity approximately equal to $2N$.

158. (Original) The coupled inductor regulator of Claim 155 wherein the pairs of inductors of a stage of the lattice network are in communication with an inductor of a previous stage of the lattice network such that each stage of the lattice network has twice as many inductors as the previous stage.

159. (Original) The coupled inductor regulator of Claim 155 wherein the pairs of inductors are each wound on corresponding single magnetic core structures.

160. (Original) The coupled inductor regulator of Claim 155 wherein N is equal to two and the output voltage is approximately equal to one-fourth of the input voltage.

161. (Original) The coupled inductor regulator of Claim 160 wherein the pairs of inductors are each wound on corresponding single magnetic core structures.

162. (Original) The coupled inductor regulator of Claim 160 wherein the phase signals are arranged in a timing sequence selected from a group consisting of sequential and alternating.

163. (Original) The coupled inductor regulator of Claim 162 an intermediate frequency of the lattice network with the alternating timing sequence is greater than the intermediate frequency of the lattice network with the sequential timing sequence.

164. (Original) A coupled inductor regulator for converting energy from a source of input voltage to an output having an output voltage, comprising:

at least two phase signals to control a conduction time;

at least two means for conducting, responsive to the at least two phase signals, to conduct energy from the source of input voltage;

a lattice network of coupled inductors in communication between the at least two means for conducting and the output, the lattice network having N stages wherein N is at least one, pairs of the coupled inductors within each of the stages each having a coefficient of coupling approximately equal to one;

the phase signals each having a duty cycle of approximately $100\%/2N$;
and

the output voltage approximately equal to the input voltage divided by $2N$.

165. (Original) The coupled inductor regulator of Claim 164 wherein the at least two phase signals have a quantity approximately equal to $2N$.

166. (Original) The coupled inductor regulator of Claim 164 wherein the at least two means for conducting have a quantity approximately equal to $2N$.

167. (Original) The coupled inductor regulator of Claim 164 wherein the pairs of inductors of a stage of the lattice network are in communication with an inductor of a previous stage of the lattice network such that each stage of the lattice network has twice as many inductors as the previous stage.

168. (Original) The coupled inductor regulator of Claim 164 wherein the pairs of inductors are each wound on corresponding single means for magnetic coupling.

169. (Original) The coupled inductor regulator of Claim 164 wherein N is equal to two and the output voltage is approximately equal to one-fourth of the input voltage.

170. (Original) The coupled inductor regulator of Claim 169 wherein the pairs of inductors are each wound on corresponding single means for magnetic coupling.

171. (Original) The coupled inductor regulator of Claim 169 wherein the phase signals are arranged in a timing sequence selected from a group consisting of sequential and alternating.

172. (Original) The coupled inductor regulator of Claim 171 an intermediate frequency of the lattice network with the alternating timing sequence is greater than the intermediate frequency of the lattice network with the sequential timing sequence.

173.-186. (Cancelled)

187. (Previously Presented) The coupled inductor regulator of Claim 1 wherein a combined conduction time of said at least two conduction switches approaches but is less than 100%.

188. (Previously Presented) The coupled inductor regulator of Claim 1 wherein said at least two conduction switches include a first conduction switch that receives a first drive signal and a second conduction switch that receives a second drive signal,

wherein said at least two freewheeling switches include a first freewheeling switch that receives said second drive signal and a second freewheeling switch that receives said first drive signal, and wherein said first and second drive signals are the same signal with a phase offset that is equal to 360 degrees divided by a number of said conduction switches.

189.-239. (Cancelled)

240. (Previously Presented) The coupled inductor regulator of Claim 1 wherein a first conduction time of one of said conduction switches is separated from a second conduction time of another of said conduction switches by non-conduction time, wherein a duration of said non-conduction time is substantially less than a duration of both said first conduction time and said second conduction time.

241. (Previously Presented) The coupled inductor regulator of Claim 75 wherein a first conduction time of one of said at least two means for conduction switching is separated from a second conduction time of another of said at least two means for conduction switching by non-conduction time, and wherein a duration of said non-conduction time is substantially less than a duration of both said first conduction time and said second conduction time.

242. (Previously Presented) The coupled inductor regulator of Claim 75 wherein said at least two means for conduction switching have a combined conduction time that approaches but is less than 100%.

243. (Previously Presented) The coupled inductor regulator of Claim 75 wherein one of said at least two means for conduction switching receives a first drive signal, another of said at least two means for conduction switching receives a second drive signal, one of said at least two means for freewheeling switching receives said second drive signal, and another of said at least two means for freewheeling switching receives said first drive signal, and wherein said first and second drive signals are the same signal with a phase offset that is equal to 360 degrees divided by a number of said conduction switches.